AUGUST 1985 VOL. 10, NO. 8

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BYTE

THE SMALL SYSTEMS JOURNAL

THE AMIGA from Commodore

DECLARATIVE LANGUAGES:
Prolog, Hope, FP

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No matter what b you're in

Candidate Search Update

FILE: *Resumes*
SEARCH DATE: *5/20/85*
CLIENT: *Splendora Gourmet Baby Foods*

FIND
EXPERIENCE = *Marketing Manager*
FIELD = *Foods/Infant*
SIZE = *500+ Employees*
SALARY REQ.= *$40-$50,000 Per Annum*
LOCATION REQ.= *Detroit*
-or-
RELOCATABLE = *Yes*

Name	Experience	Salary	Education	Age
Antosz, Hank	1978—Present Pinz-Pinz Baby Food 1976—1978 Heath Baby Products	$45,000	Harvard MBA/Mktg.	33
Brown, Bob	1984—Present Liz for Kids 1982—1984 Bonnie Babe, Inc.	$48,000	CSUN/Marketing BA	26
Hayden, Steve	1979—Present Heath Baby Products 1975—1979 Nummy Tummies	$43,000	UCLA/Sociology BA Harvard MBA	35
Morrison, John	1977—Present Camille Grocers, Ltd. 1974—1977 Georgie Porgie of London	$40,000	Oxford/Marketing	32
West, Nick	1961—Present Bonnie Babe, Inc.	$47,000	UCLA MBA/Mktg.	42

Recruit-A-Suit
100 Aldous Avenue
Suite 7-J
Detroit, Michigan

May 20, 1985

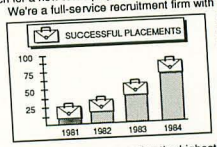
Mr. Greg Helm
Vice President, Marketing
Splendora Gourmet Baby Foods
2200 Michigan Place East
Winnetka, Illinois

Dear Mr. Helm:

As a busy executive you know that accomplishing your many professional objectives is a full-time job.

And the last thing you need is to take time out of your hectic schedule to search for a new team player. That's where Recruit-A-Suit can help!

We're a full-service recruitment firm with our finger on *more than 5,000*, meticulously selected, aggressive, ambitious, highly-qualified professionals not unlike yourself.



Our selective screening processes help us locate candidates who not only meet your specified work experience and salary requirements, but who are well suited to the corporate culture of your company.

One more reason we enjoy the highest success rate in the industry! Though our fees remain among the most competitive in the industry.

Enclosed, please find more information on our client references, case histories and terms of business for your reading pleasure.

And next time you find yourself faced with an empty swivel chair, don't hesitate to call Recruit-A-Suit.

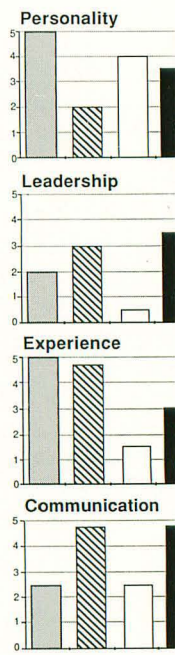
Sincerely,

Cynthia Shern

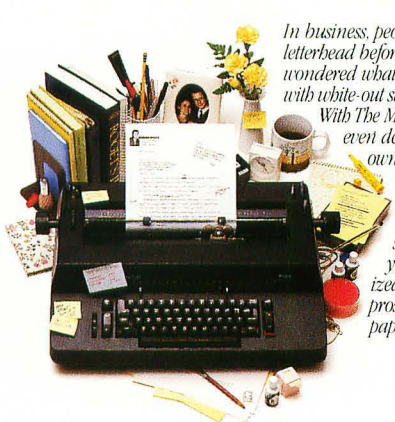
Cynthia Shern
Senior Associate

CS:dh

enc.



Using database management programs you can store, retrieve and sort information in an almost unlimited number of combinations. As opposed to the way you're probably doing it now. Above, we've located eligible candidates by salary and work experience. But database management is also handy for things like generating master mailing lists. Creating invoices. Sorting by zip code. Checking inventory. No files to lose. No cross-referencing your Rolodex.® No paperclips.



In business, people often meet your letterhead before they meet you. Ever wondered what a typewritten page stiff with white-out says about your business? With The Macintosh Office you can even design and print your own letterhead, plus combine publication quality text and graphics for a lasting first impression. More important, you can send personalized letters to as many prospects as you have paper.

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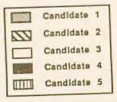
Candidate Profile Analysis



Each graph represents seven to ten pages of test information per candidate.

Individual tests are available for your review at your request.

As these comparative charts indicate, all candidates tested competitively in the four areas.

However, based on further in-depth study, including extensive personal interviews, we highly recommend you interview candidates 4 and 5 as soon as possible.

Our office will be contacting you immediately to set up these interviews at your earliest convenience.

Recruit-A-Suit Income Statement
Fiscal Year Ending 9/30/84

	Q1	Q2	Q3	Q4	Year-end
SALES					
Ann Arbor					
Fees	20,000	19,000	22,000	17,000	78,000
Commissions	52,000	45,000	48,000	42,000	187,000
Total Ann Arbor	72,000	64,000	70,000	59,000	265,000
Detroit					
Fees	44,000	46,000	42,000	39,000	171,000
Commissions	68,000	72,000	64,000	62,000	266,000
Total Detroit	112,000	118,000	106,000	101,000	437,000
TOTAL SALES	184,000	182,000	176,000	160,000	702,000
OPERATING EXPENSES					
Ann Arbor					
Payroll	30,000	30,000	33,000	30,000	123,000
Taxes	2,500	2,500	2,600	2,500	10,100
Auto	1,200	1,200	1,200	1,200	4,800
Telephone	600	600	600	600	2,400
Rent	8,000	8,000	8,000	8,000	32,000
Utilities	500	500	500	500	2,000
Dues/Subscrip.	100	100	200	100	500
Advertising	3,000	3,000	4,000	4,000	14,000
Travel	1,000	1,000	1,000	1,000	4,000
Entertainment	1,500	1,500	1,750	1,500	6,250
Office Supplies	300	300	300	300	1,200
Ann Arbor Total	48,700	48,700	53,150	49,700	200,250
Detroit					
Payroll	50,000	52,000	50,000	50,000	202,000
Taxes	4,200	4,400	4,200	4,200	17,000
Auto	2,400	2,400	2,400	2,400	9,600
Telephone	1,200	1,500	1,500	1,200	5,400
Rent	9,100	9,100	9,100	9,400	36,700
Utilities	800	800	800	800	3,200
Dues/Subscrip.	200	250	200	200	850
Advertising	3,000	3,500	3,500	3,000	13,000
Travel	1,200	1,500	1,200	1,400	5,300
Entertainment	1,600	1,800	1,600	1,400	6,400
Office Supplies	400	400	400	400	1600
Detroit Total	74,100	77,650	74,900	74,400	301,050
EXPENSES TOTAL	122,800	126,350	128,050	124,100	501,300
NET PRE-TAX PROFIT	61,200	55,650	47,950	35,900	200,700

If a picture is worth a thousand words, business graphics like these could cut meetings and presentations in half.

We've taken information on five candidates stored in one software program, copied it into another program, where it was used to create these comparative bar graphs. Once your data is entered, this particular software program gives you your choice of 42 different graph configurations. You can preview your material (whether it's candidates, costs or cookies) in each configuration to decide which chart or graph most persuasively makes your point.

*As you well know, business involves innumerable number-related tasks, not the least of which is generating income and expense statements like this one. Should you want to change any of the entered items — to take a look at the effects of opening a new office or decreasing your staff — a spreadsheet program like Multiplan** will automatically recalculate the entire document. (Here, we've copied it into MacDraw™ and enhanced it for presentation purposes.)*

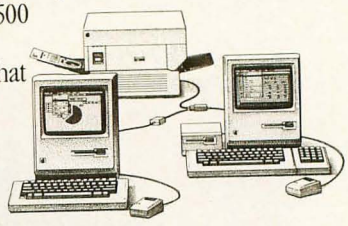
It not only saves hours of entering, double-checking and erasing, but when teamed up with our LaserWriter printer, it produces a printout impressive enough to show a bank president. Fast enough for this afternoon's meeting.

Whether you're Nabisco® or Ms. Priss' Cookie Company you worry about the bottom line. Write letters. Keep track of inventory. Keep your overhead under control. Pay taxes. Retrieve files. Schedule projects.

Which is why you can dramatically increase your business' productivity with The Macintosh™ Office.

The cornerstone of The Macintosh Office is our Macintosh 512K computer. All you need to know about its powerful, 32-bit, mouse-driven technology is that it reduces the time it takes to become productive with a computer from well over a work week to just under a lunch hour.

But more important, Macintosh runs more than 500 software programs that can solve a multitude of business problems.



When you team up Macintosh with the second hardest worker in The Macintosh Office, our LaserWriter™ printer, you can bring a new level of professionalism to your paperwork.

It produces publication-quality text and graphics in letters, internal documents, presentations, even business forms. There's no telling what it can save you in outside printing costs alone. And the LaserWriter can be shared with as many as 31 Macintosh computers. So it becomes more cost efficient with every Macintosh you connect to it.

Butcher, baker, candlestick-maker... or Nabisco, for more information about The Macintosh Office call 800-446-3000.

No job too big.
Or too small.

The Macintosh Office.

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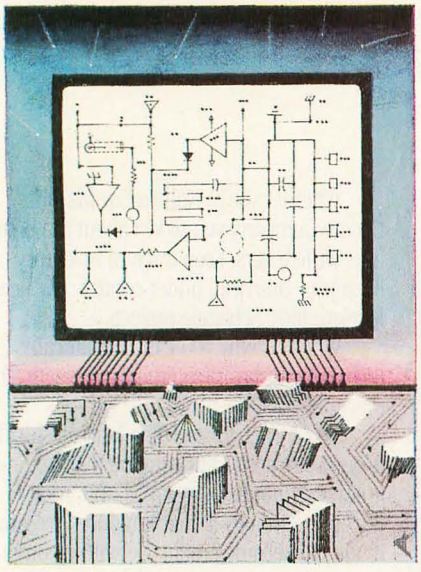
C·O·N·T·E·N·T·S



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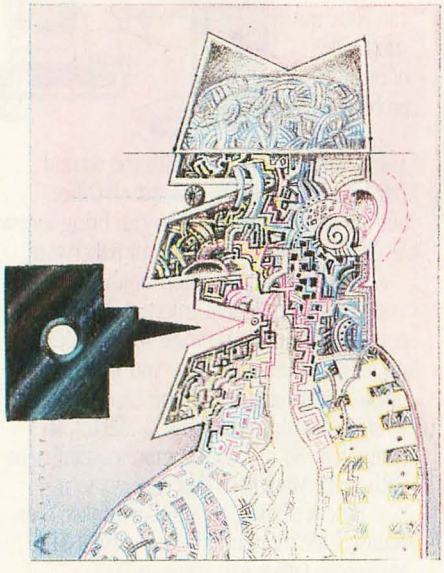

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COVER PHOTO BY AARON REZNY WITH APOLOGIES TO PABLO PICASSO

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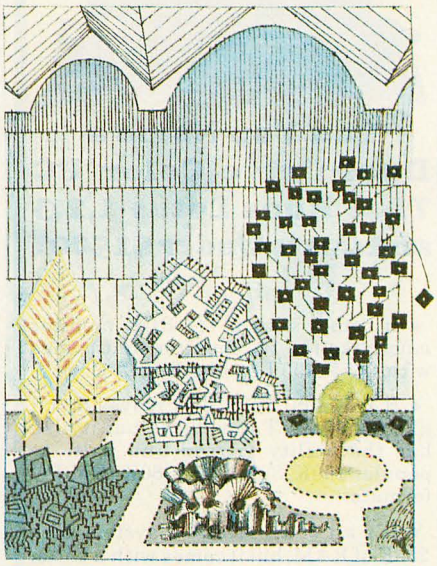

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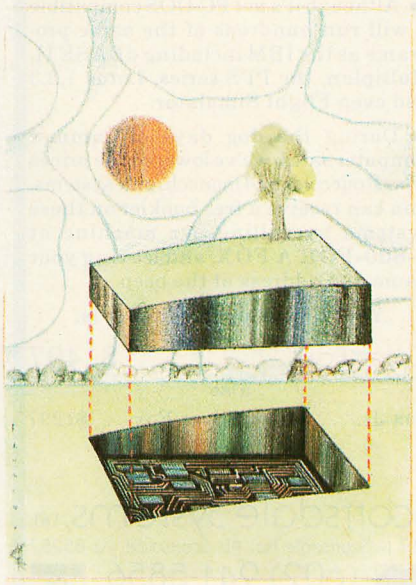

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SECTION ART BY MACIEK ALBRECHT

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Can You Name a Dual-Drive Color PC That Runs Lotus 1,2,3 and Costs Under $1500?

Hints

- It comes with a 14" RGB monitor much like the 14" monitor that comes with the $2495 Leading Edge PC.
- It has dual 800K disk drives much like the $2495 Tandy 2000, but it also has the ability to read and write to popular 160K, 320K, and 360K IBM-PC formats.
- It's an 8088, MS-DOS system with 256K of RAM, but it comes with a better free software bundle than the 8-bit Kaypro including MS-DOS 2.11, HAGEN-DOS, DOS-TUTOR, WordStar 3.3, EasyWriter, Spell, Mail Track, PC File III, FILEBASE, CalcStar, games, graphics, utilities, and two BASIC languages.
- Although it's not PC-DOS compatible it will run hundreds of the same programs as the IBM including dBASE II, Multiplan, the PFS series, Lotus 1,2,3 and even Flight Simulator.
- During the dog days of summer computer sales, we've lowered the prices of both our color and monochrome systems. You can receive a free booklet on these systems by calling our machine at **1-800-FOR A FOX**, and leaving your name and address at the beep.

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BUILD THE BASIC-52 COMPUTER/ CONTROLLER

BY STEVE CIARCIA

A single-board problem solver with great potential

One of the most popular Circuit Cellar projects was the Z8 BASIC computer/controller presented in July and August of 1981. Since then, thousands of Z8 controller boards have found their way into end-user and OEM applications.

I specifically designed the original Z8 controller because I hate programming. Generally speaking, if the program has fewer than 100 lines I'll grin and bear it. Any longer than that, however, and I lose interest and call in a programmer. To ease the pain, I generally use high-level languages like BASIC. Most people understand BASIC, and it excuses me from wasting time on tedious bit manipulations merely to demonstrate a hardware peripheral device. (My favorite programming language is solder.)

I don't try to justify using BASIC, I just get results. While others are arguing the merits of Pascal and C, I've plugged in my single-board computer/controller and am plinking away in BASIC to solve the problem. I've learned enough about other programming languages so that I know when to nod appreciatively at a programmer's description of a random-number seed generator written in some obscure programming dialect.

This "plug and program" approach has been adequately satisfied by the Z8, but I find that I purposely avoid applications involving floating-point calculations or trigonometric functions that would otherwise force me to resort to assembly-language programming (ugh!). In an effort to forestall my inevitable defection from BASIC, I am continually on the lookout for cost-effective performance boosters that I can package as single-board problem solvers (that execute in BASIC, naturally). And I just found another one!

What I have found is the Circuit Cellar BASIC-52 computer/controller (BCC-52) board. It uses the new Intel 8052AH-BASIC microcontroller chip that contains a ROM (read-only memory)-resident 8K-byte BASIC interpreter. The BCC-52 board includes the 8052AH, 48K bytes of RAM/EPROM (random-access read/write memory/erasable programmable ROM), a 2764/128 EPROM programmer, three parallel ports, a serial terminal port with automatic data-transmission-rate selection, a serial printer port, and is bus-compatible with the BCC-11 Z8 system/controller and all the BCC-series expansion boards I've already designed. Figure 1

(continued)

Steve Ciarcia (pronounced "see-ARE-see-ah") is an electronics engineer and computer consultant with experience in process control, digital design, nuclear instrumentation, and product development. He is the author of several books about electronics. You can write to him at POB 582, *Glastonbury,* CT 06033.

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is a block diagram of the hardware.

BASIC-52 is particularly suited for process control, providing IF. . . THEN, FOR. . . NEXT, DO. . . WHILE/UNTIL, ONTIME, and CALL statements among its broad repertoire of instructions (figure 2 lists the software features). Calculations are handled in integer or floating-point math and are fully supported with trigonometric and logical operators. Because of its low system overhead it is extremely fast and efficient.

I'll get into the system configuration and the design details momentarily, but I first have to mention an interesting aspect of BASIC-52. While I considered using EEPROMS (electrically erasable programmable ROMs) and other nonvolatile storage techniques, the sophisticated EPROM programming capabilities of BASIC-52 justified eliminating them simply on the basis of cost and board real estate. Unlike most one-shot EPROM programmers that fill the entire contents of an EPROM regardless of the application program's size, BASIC-52 treats the EPROM as write-once mass storage.

When a BASIC application program is saved to EPROM, it is tagged with an identifying ROM number and stored only in the amount of EPROM required to fit the program (plus header and EOF [end of file]). Additional application programs can be stored to the same EPROM and recalled for execution by requesting a particular ROM number. A 27128 EPROM provides 16K bytes of mass-storage space. When it is full (a nondestructive EPROM FULL error will tell you), simply erase the present EPROM or insert another. Finally, since this pseudo–mass storage exists in directly addressable memory space rather than cassettes or disks, it runs at full processor speed and stored application programs are instantly accessible.

BASIC-52 bridges the gap between expensive, intelligent control capabilities and hard-to-justify, price-sensitive control applications. BASIC-52's full floating-point BASIC is fast and efficient enough for the most complicated tasks, while its cost-effective design lets it be considered for many new areas of implementation.

I'm bullish on the BCC-52 board, and you can expect to see it in future Circuit Cellar projects. With so much power and convenience, I can accomplish quite a bit in a few lines of code—especially since that's all I may ever write.

THE BCC-52 BOARD

The BCC-52 is a single-board controller/development system. Shown as a prototype in photo 1 and as a schematic in figure 3, this 17-chip circuit fits in a compact 4½ by 6½ inches (the same size as the Term-Mite smart terminal [see photo 2], if you want a two-board complete system—see my columns in the January and February 1984 issues of BYTE). It contains RAM/EPROM, an EPROM programmer, three parallel ports, and two serial ports.

The BCC-52 board has five main sections: processor, address decoding and memory, parallel I/O (input/output), serial I/O, and EPROM programmer.

The BCC-52 board is based on the 8052AH-BASIC chip, a preprogrammed version of Intel's 8052AH microcontroller (see figure 4). The 8052AH is the newest of Intel's 8-bit microcontroller-chip series, also known as the MCS-51 family.

The 8052AH contains 8K bytes of on-chip ROM, 256 bytes of RAM, three 16-bit counter/timers, six interrupts, and 32 I/O lines. In the 8052AH-BASIC chip, the ROM is a masked BASIC interpreter, and the I/O lines are redefined to address, data, and control lines. Figure 5a illustrates the 8052AH-BASIC chip pinout.

The 8052AH-BASIC chip has a 16-bit address and an 8-bit data bus (the 8 least significant address bits [AD0–AD7] and the data bus [D0–D7] are multiplexed together, similar to

(continued)

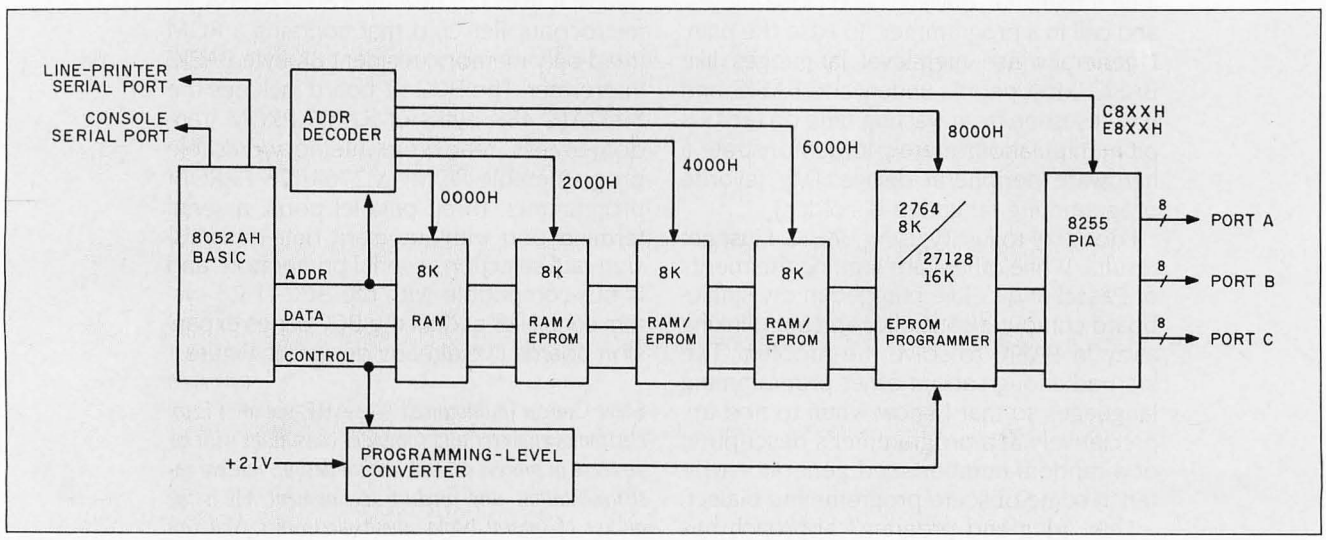

Figure 1: *Block diagram of the Circuit Cellar* BASIC-52 *computer/controller board.*

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Command	Function
RUN	Execute a program
CONT	Continue after a stop or Control-C
LIST	List program to the console device
LIST#	List program to serial printer
NEW	Erase the program stored in RAM
NULL	Set null count after carriage return/line feed
RAM	Evoke RAM mode, current program in read/write memory
ROM	Evoke ROM mode, current program in ROM/EPROM
XFER	Transfer a program from ROM/EPROM to RAM
PROG	Save the current program in EPROM
PROG1	Save data-transmission-rate information in EPROM
PROG2	Save data-transmission-rate information in EPROM and execute program after reset
FPROG	Save the current program in EPROM using the intelligent algorithm
FPROG1	Save data-transmission-rate information in EPROM using the intelligent algorithm
FPROG2	Save data-transmission-rate information in EPROM and execute program after reset, use intelligent algorithm

Statement	Function
BAUD	Set data-transmission rate for line-printer port
CALL	Call assembly-language program
CLEAR	Clear variables, interrupts, and strings
CLEARS	Clear stacks
CLEAR1	Clear interrupts
CLOCK1	Enable real-time clock
CLOCK0	Disable real-time clock
DATA	Data to be read by READ statement
READ	Read data in DATA statement
RESTORE	Restore read pointer
DIM	Allocate memory for arrayed variables
DO	Set up loop for WHILE or UNTIL
UNTIL	Test DO loop condition (loop if false)
WHILE	Test DO loop condition (loop if true)
END	Terminate program execution
FOR-TO-{STEP}	Set up FOR. . .NEXT loop
NEXT	Test FOR. . .NEXT loop condition
GOSUB	Execute subroutine
RETURN	Return from subroutine
GOTO	GOTO program line number
ON GOTO	Conditional GOTO
ON GOSUB	Conditional GOSUB
IF-THEN-{ELSE}	Conditional test
INPUT	Input a string or variable
LET	Assign a variable or string a value (LET is optional)
ONERR	ONERR or GOTO line number
ONTIME	Generate an interrupt when time is equal to or greater than ONTIME argument; line number is after comma
ONEX1	GOSUB to line number following ONEX1 when INT1 pin is pulled low
PRINT	Print variables, strings, or literals, P. is shorthand for print
PRINT#	Print to software serial port
PH0.	Print hexadecimal mode with zero suppression
PH1.	Print hexadecimal mode with no zero suppression
PH0.#	PH0.# to line printer
PH1.#	PH1.# to line printer
PUSH	Push expressions on argument stack

Statement	Function
POP	Pop argument stack to variables
PWM	Pulse-width modulation
REM	Remark
RETI	Return from interrupt
STOP	Break program execution
STRING	Allocate memory for strings
UI1	Evoke user console input routine
UI0	Evoke BASIC console input routine
UO1	Evoke user console output routine
UO0	Evoke BASIC console output routine

Operator	Function
CBY( )	Read program memory
DBY( )	Read/assign internal data memory
XBY( )	Read/assign external data memory
GET	Read console
IE	Read/assign IE register
IP	Read/assign IP register
PORT1	Read/assign I/O port 1 (P1)
PCON	Read/assign PCON register
RCAP2	Read/assign RCAP2 (RCAP2H:RCAP2L)
T2CON	Read/assign T2CON register
TCON	Read/assign TCON register
TMOD	Read/assign TMOD register
TIME	Read/assign real-time clock
TIMER0	Read/assign TIMER0 (TH0:TL0)
TIMER1	Read/assign TIMER1 (TH1:TL1)
TIMER2	Read/assign TIMER2 (TH2:TL2)
+	Addition
/	Division
**	Exponentiation
*	Multiplication
–	Subtraction
.AND.	Logical AND
.OR.	Logical OR
.XOR.	Logical exclusive OR

Stored Constant

PI	PI – 3.1415926

Operators—Single Operand

ABS( )	Absolute value
NOT( )	One's complement
INT( )	Integer
SGN( )	Sign
SQR( )	Square root
RND	Random number
LOG( )	Natural log
EXP( )	"e" (2.7182818) to the X
SIN( )	Returns the sine of argument
COS( )	Returns the cosine of argument
TAN( )	Returns the tangent of argument
ATN( )	Returns the arctangent of argument

Figure 2: *Detailed description of the Intel 8052AH BASIC-52 programming language.*

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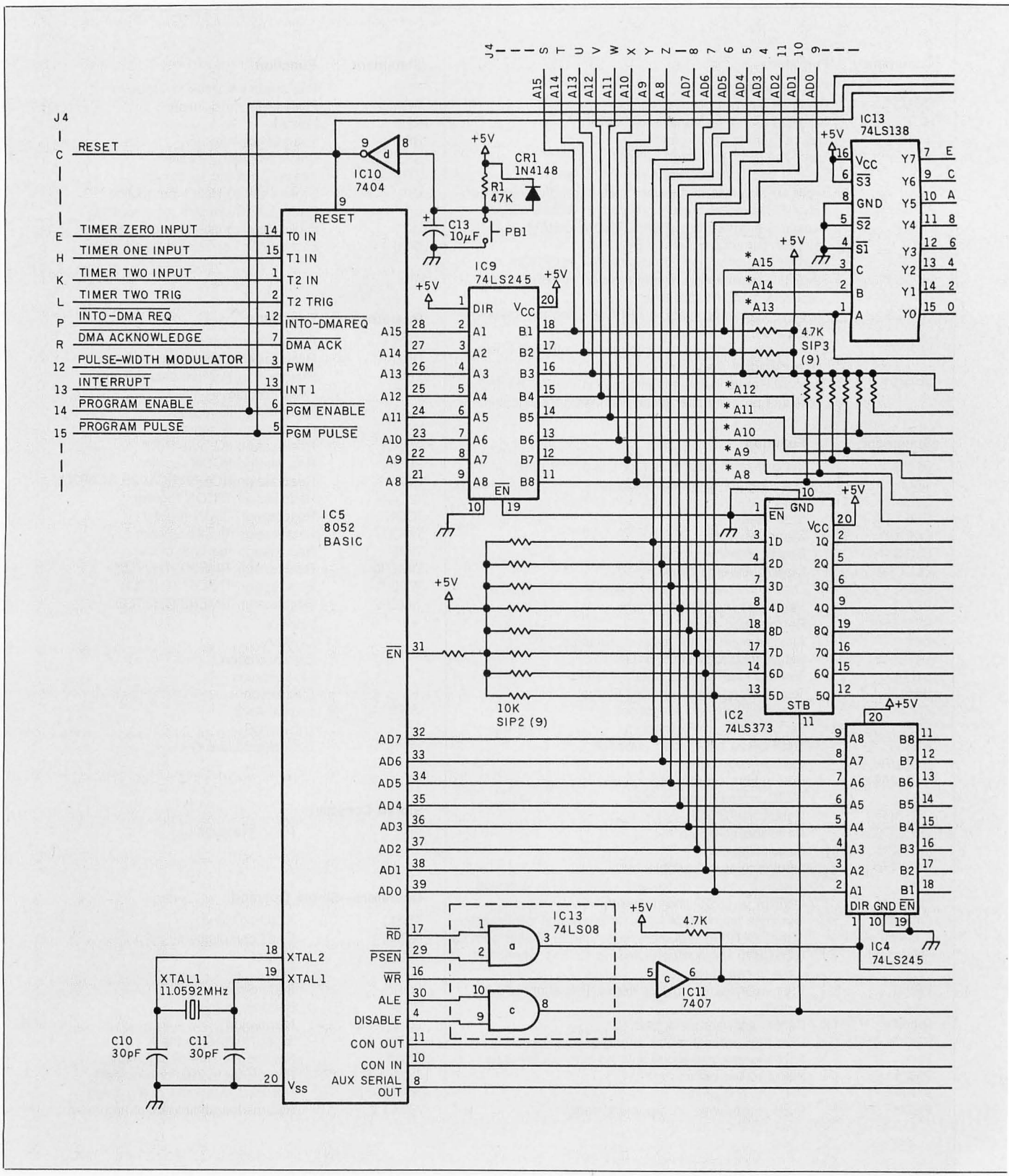

Figure 3: *Schematic diagram of the* BCC-52 *board.*

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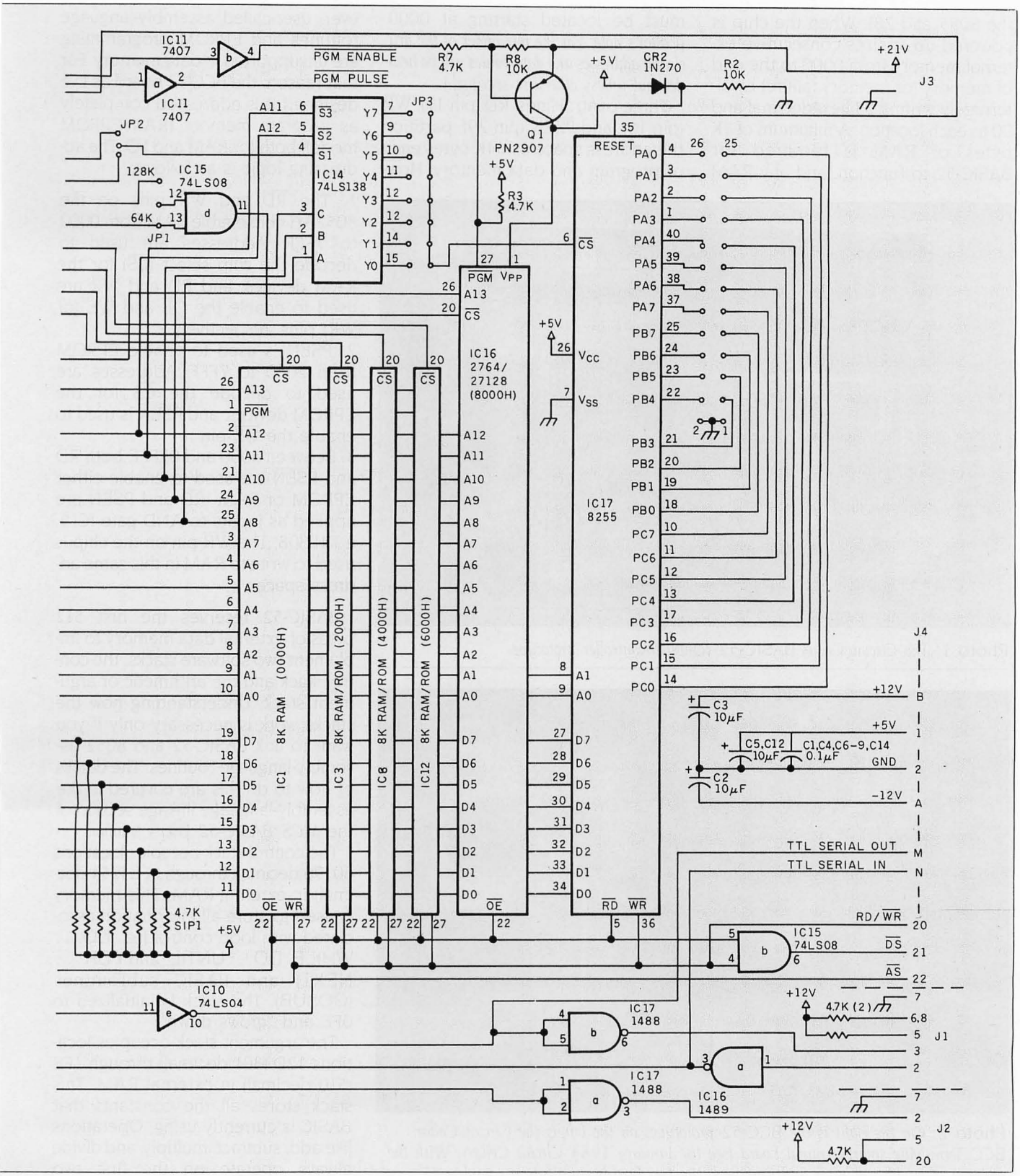

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the 8085 and Z8). When the chip is powered up, it sizes consecutive external memory from 0000 to the end of memory (or memory failure) by alternately writing 55 hexadecimal and 00 to each location. A minimum of 1K bytes of RAM is required for BASIC-52 to function, and any RAM must be located starting at 0000. [*Editor's note: For the remainder of the article, all addresses and data values will be hexadecimal unless otherwise specified.*]

Three control lines, $\overline{RD}$ (pin 17), $\overline{WR}$ (pin 16), and $\overline{PSEN}$ (pin 29), partition the address space as 64K bytes each of program and data memory. However, user-called assembly-language routines and EPROM programming are unsupported in data memory. For that reason, the BCC-52 board as I've designed it is addressed completely as program memory (RAM/EPROM mode), both for RAM and I/O. The addressing logic is as follows:

1. The $\overline{RD}$ and $\overline{WR}$ pins on the 8052AH chip enable RAM from 0000 to 7FFF. Addresses are used to decode the chip select ($\overline{CS}$) for the RAM devices, and $\overline{RD}$ and $\overline{WR}$ are used to enable the $\overline{OE}$ and $\overline{WE}$ (or $\overline{WR}$) pins, respectively.
2. $\overline{PSEN}$ is used to enable EPROM from 2000 to 7FFF. Addresses are used to decode the $\overline{CS}$ for the EPROM devices, and $\overline{PSEN}$ is used to enable the $\overline{OE}$ pin.
3. Between 8000 and 0FFFF, both $\overline{RD}$ and $\overline{PSEN}$ are used to enable either EPROM or RAM. $\overline{RD}$ and $\overline{PSEN}$ are applied as inputs to AND gate IC15, a 74LS08. The $\overline{WR}$ pin on the chip is used to write to RAM in this same address space.

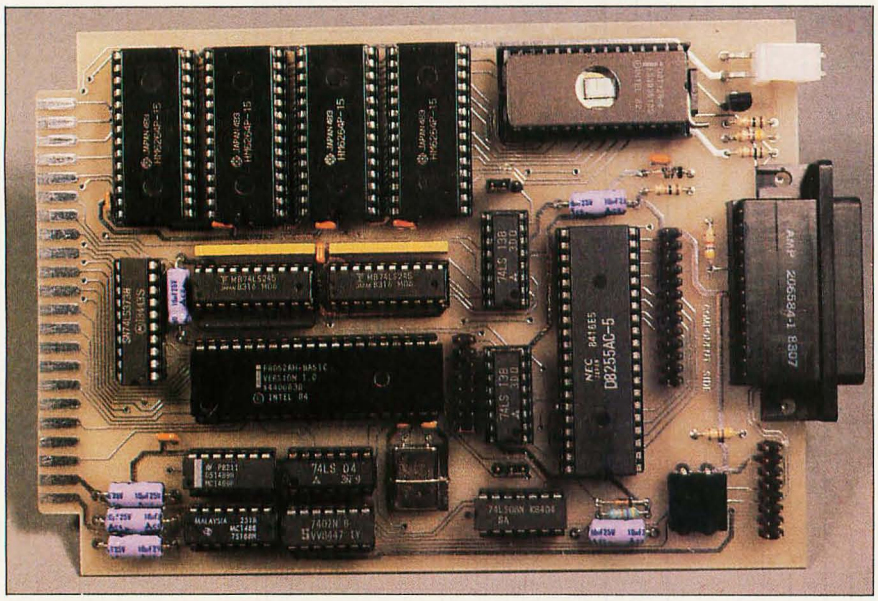

Photo 1: *The Circuit Cellar* BASIC-52 *computer/controller prototype.*

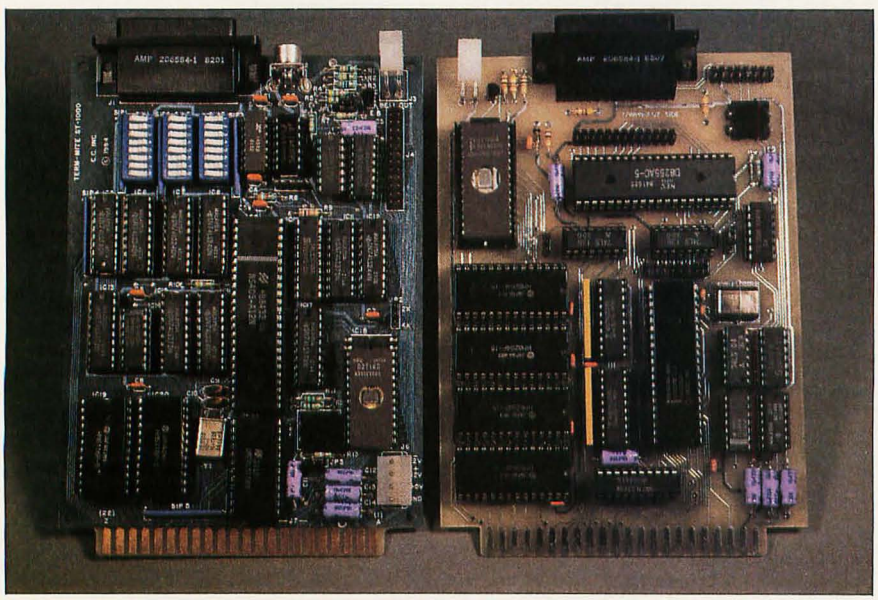

Photo 2: *On the right is the* BCC-52 *prototype; on the left is the Circuit Cellar* BCC *Term-Mite smart-terminal board (see the January* 1984 *Circuit Cellar). With the addition of a video monitor and keyboard, the two boards constitute a complete computer system suitable for software development or installed use.*

BASIC-52 reserves the first 512 bytes of external data memory to implement two software stacks: the control stack and the arithmetic or argument stack. Understanding how the stacks work is necessary only if you want to link BASIC-52 and 8052 assembly-language routines. The details of how to do this are covered in the assembly-language linkage section of the *MCS BASIC-52 User's Manual*.

The control stack occupies locations 60 (96 decimal) through 0FE (254 decimal) in external RAM. This memory is used to store all information associated with loop control (i.e., DO. . . WHILE, DO. . .UNTIL, and FOR. . . NEXT) and BASIC subroutines (GOSUB). The stack is initialized to 0FE and "grows down."

The argument stack occupies locations 12D (301 decimal) through 1FE (510 decimal) in external RAM. This stack stores all the constants that BASIC is currently using. Operations like add, subtract, multiply, and divide always operate on the first two numbers on the argument stack and return the result to the argument

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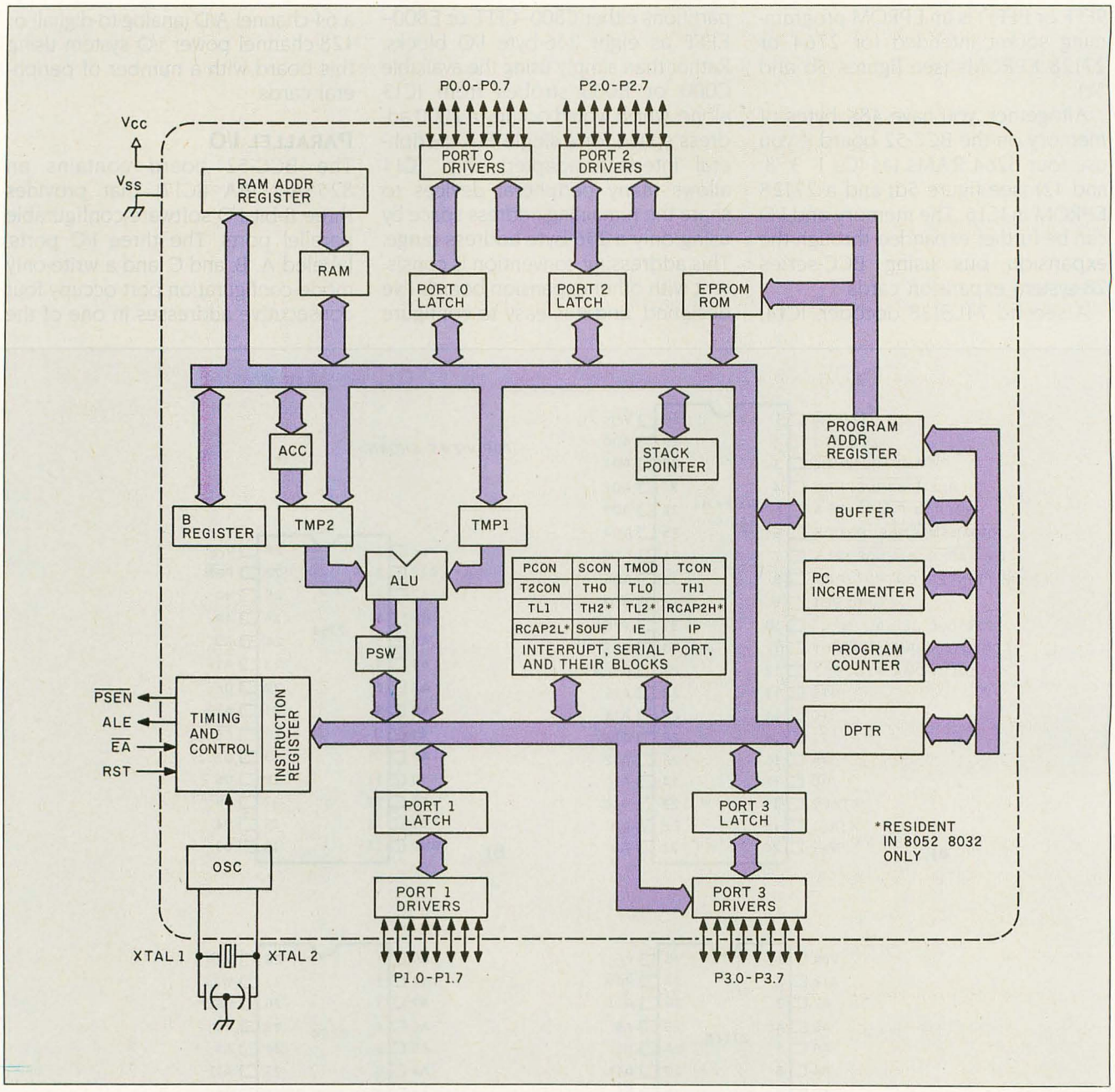

Figure 4: *Block diagram of the Intel* 8052AH-BASIC *chip.*

stack. The argument stack is initialized to 1FE and "grows down" as more values are placed on it. Each floating-point number placed on the argument stack requires 6 bytes of storage.

The stack pointer on the 8052AH (special-function register, SP) is initialized to 4D (77 decimal). The 8052AH's stack pointer "grows up" as additional values are placed on the stack.

Address Decoding

The three most significant address lines (A13–A15) are connected to a 74LS138 decoder chip, IC13, which separates the addressable range into eight 8K-byte memory segments, each with its own chip select (Y0–Y7). The four least significant chip selects are connected to 28-pin, 64K-bit (8K by 8) memory devices, either 2764 EPROMs or 6264 static RAMs. IC1, addressed at 0000, must be RAM in order for BASIC-52 to function. IC locations 3 (2000–3FFF), 11 (4000–5FFF), and 12 (6000–7FFF) can use either RAM or EPROM. IC16 (8000–

(continued)

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9FFF or BFFF) is an EPROM programming socket intended for 2764 or 27128 EPROMs (see figures 5b and 5c).

Altogether, you have 48K bytes of memory on the BCC-52 board if you use four 6264 RAMs (as ICs 1, 3, 8, and 12) (see figure 5d) and a 27128 EPROM in IC16. The memory and I/O can be further expanded through the expansion bus using BCC-series Z8-system expansion cards.

A second 74LS138 decoder, IC14, partitions either C800–CFFF or E800–EFFF as eight 256-byte I/O blocks. Rather than simply using the available C000 or E000 strobes from IC13 alone, which would occupy a 2000 address space for a single PIA (peripheral interface adapter) chip, IC14 allows many peripheral devices to share the remaining address space by using only a 256-byte address range. This addressing convention is consistent with other expansion boards I've designed, and it is easy to configure a 64-channel A/D (analog-to-digital) or 128-channel power I/O system using this board with a number of peripheral cards.

PARALLEL I/O

The BCC-52 board contains an 8255A-5 PIA (IC17) that provides three 8-bit I/O software-configurable parallel ports. The three I/O ports, labeled A, B, and C, and a write-only mode-configuration port occupy four consecutive addresses in one of the

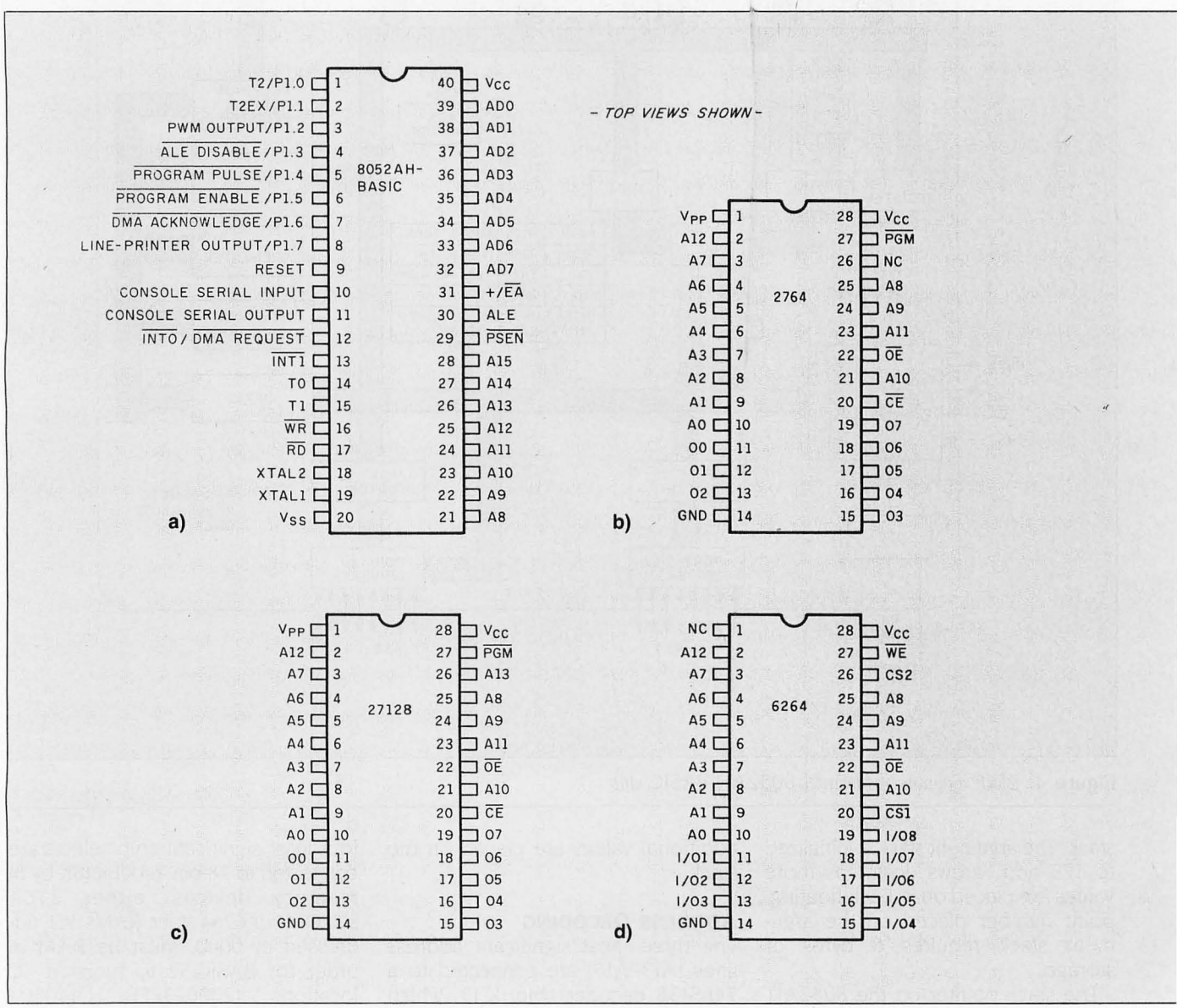

Figure 5: *Pinouts for (a) the* 8052AH-BASIC *chip, (b) the* 2764 8K-*byte* EPROM, *(c) the* 27128 16K-*byte* EPROM, *and (d) the* 6264 8K-*byte* RAM.

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eight jumper-selectable I/O blocks. With C000 selected and pin 17 of IC14 (Y0) jumpered to pin 6 of IC17 (at JP3), the range would be C800–C803. Using the XBY() operator in BASIC, data can be written to and read from this PIA. (You are probably more familiar with PEEK and POKE. PEEK (C802H) is accomplished with XBY (C802H), and POKE C902H,A is XBY(C802H) = A.) I won't belabor the discussion on the 8255. I have used it many times in Circuit Cellar projects and refer you to the manufacturer's data sheets.

The three parallel ports and ground are connected to a 26-pin flat ribbon-cable connector. The outputs are TTL (transistor-transistor logic)-compatible.

SERIAL I/O

Two serial ports are found on the BCC-52 board. One is for the console I/O terminal (IC5 pins 10 and 11); the other is an auxiliary serial output (IC5 pin 8) frequently referred to as the line-printer port. When using an 11.0592-megahertz (MHz) crystal, the console port does automatic data-transmission-rate determination on power-up (a preset data-transmission rate can alternatively be stored in EPROM as well). I've used it at 19,200 bits per second (bps) with no degradation in operation.

The BAUD[expr] statement is used to set the data-transmission rate for the line-printer port. In order for this statement to properly calculate the data-transmission rate, the crystal (special-function operator—XTAL) must be correctly assigned (e.g., XTAL = 9000000). BASIC-52 assumes a crystal value of 11.0592 MHz if no XTAL value is assigned.

The main purpose of the software line-printer port is to let you make a hard copy of program listings and/or data. The command LIST# and the statement PRINT# direct outputs to the software line-printer port. If the BAUD[expr] statement is not executed before a LIST# or PRINT# command/statement is entered, the output to the software line-printer port will be at about 1 bps, and it will take a long time to output something. It is necessary to assign a data-transmission rate to the software line-printer port before using LIST# or PRINT#. The maximum data-transmission rate that can be assigned by the BAUD[expr] statement depends on the crystal, but 4800 bps is a reasonable maximum rate.

MC1488 and 1489 level shifters (ICs 6 and 7) convert the TTL levels from the console and line-printer ports to RS-232C. (The TTL serial lines are also connected to the bus to allow use of the Term-Mite smart-terminal board without RS-232C voltages.) The BCC-52 board requires only about 200 milliamperes (mA) at +5 volts (V) to function. The voltage required for external RS-232C communication is ±12 V; that required for EPROM programming is +21 V.

EPROM PROGRAMMER

One of the more unique and powerful features of the BCC-52 board is its

(continued)

■ Mode Selection (goes with figure 5b)

Mode \ Pins	$\overline{CE}$ (20)	$\overline{OE}$ (22)	$\overline{PGM}$ (27)	V_{PP} (1)	V_{CC} (28)	Outputs (11–13, 15–19)
Read	V_{IL}	V_{IL}	V_{IN}	V_{CC}	V_{CC}	Dout
Standby	V_{IN}	×	×	V_{CC}	V_{CC}	High Z
Program	V_{IL}	×	V_{IL}	V_{PP}	V_{CC}	Din
Program Verify	V_{IL}	V_{IL}	V_{IN}	V_{PP}	V_{CC}	Dout
Program Inhibit	V_{IN}	×	×	V_{PP}	V_{CC}	High Z

■ Mode Selection (goes with figure 5c)

Mode \ Pins	$\overline{CE}$ (20)	$\overline{OE}$ (22)	$\overline{PGM}$ (27)	V_{PP} (1)	V_{CC} (28)	Outputs (11–13, 15–19)
Read	V_{IL}	V_{IL}	V_{IN}	V_{CC}	V_{CC}	Dout
Standby	V_{IN}	×	×	V_{CC}	V_{CC}	High Z
Program	V_{IL}	×	V_{IL}	V_{PP}	V_{CC}	Din
Program Verify	V_{IL}	V_{IL}	V_{IN}	V_{PP}	V_{CC}	Dout
Program Inhibit	V_{IN}	×	×	V_{PP}	V_{CC}	High Z

■ Mode Selection (goes with figure 5d)

$\overline{WE}$	$\overline{CS_1}$	CS_2	$\overline{OE}$	Mode	I/O Pin
×	H	×	×	Not Selected (Power Down)	High Z
×	×	L	×		High Z
H	L	H	H	Output Disabled	High Z
H	L	H	L	Read	Dout
L	L	H	H	Write	Din
L	L	H	L		Din

×: don't care

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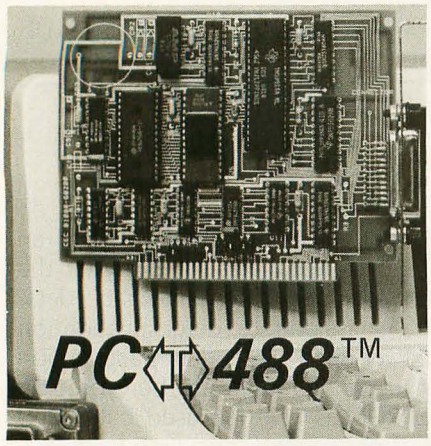
Inquiry 50



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ability to execute and save programs in an EPROM. The 8052AH chip actually generates all the timing signals needed to program 2764/128 EPROMs. Saving programs in EPROMs is a much more attractive and reliable alternative to cassette tape, especially in control and/or noisy environments.

The entire EPROM programming circuitry consists of two 7407 open-collector drivers and a single transistor circuit that switches between +5 V and 21 V (CR2, connected to the collector of the transistor should be a germanium diode like a 1N270).

Port 1, bit 4 (IC5 pin 5) is used to provide a 1- or 50-millisecond (ms) programming pulse. The length of the pulse is determined by whether we are programming Intel fast-program EPROMs or generic 2764s and 27128s. BASIC-52 calculates the length of the pulse from the assigned crystal value. The accuracy of this pulse is within 10 processor clock cycles. This pin is normally in a logical high (1) state. It is asserted low (0) to program the EPROMs.

Port 1, bit 5 (IC5 pin 6) is used to enable the EPROM programming voltage. This pin is normally in a logical high (1) state. Prior to the EPROM programming operation, this pin is brought to a logical low (0) state, and it is used to turn on the high voltage (21 V) required to program the EPROMs on or off.

BASIC-52 saves several programs on a single EPROM. In fact, it can save as many programs as the size of the EPROM permits. The programs are stored sequentially in the EPROM, and any program can be retrieved and executed. This sequential storage of programs is referred to as the EPROM file. The following commands permit you to generate and manipulate the EPROM file.

RAM and ROM[integer] tell the BASIC-52 interpreter whether to select the current program (the one that will be displayed during a LIST# command and executed when RUN is typed) out of RAM or EPROM. The RAM address is assumed to be 200 (512 decimal), and the EPROM address begins at 8010 (32,784 decimal).

When RAM is entered, BASIC-52 selects the current program from RAM. This is usually considered the normal mode of operation and is the mode that most users employ to interact with the command interpreter.

When ROM[integer] is entered, BASIC-52 selects the current program out of EPROM. If no integer is typed after the ROM command (i.e., ROM(cr)), BASIC-52 defaults to ROM 1. Since the programs are stored sequentially in EPROM, the integer following the ROM command selects which program you want to run or list. If you attempt to select a program that does not exist (i.e., you type in ROM 8 and only six programs are stored in the EPROM), the message Error: Prom Mode will be displayed. The error is nondestructive, and you can retype the correct command.

BASIC-52 does not transfer the program from EPROM to RAM when the ROM mode is selected, and you cannot edit a program in ROM. Attempting to do so will result in an error message.

Since the ROM command does not transfer a program to RAM, it is possible to have different programs in ROM and RAM simultaneously. You can flip back and forth between the two modes at any time. Another benefit of not transferring a program to RAM is that all the RAM can be used for variable storage if the program is stored in EPROM. The system-control values, MTOP and FREE, always refer to RAM.

The XFER (transfer) command transfers the currently selected program in EPROM to RAM and then selects the RAM mode. After the XFER command is executed, you can edit the program in the same manner any RAM program can be edited.

The PROG command programs the resident EPROM with the current program (this is the only time that the +21-V programming voltage needs to be applied). The current program can reside in either RAM or EPROM. After PROG is typed, BASIC-52 displays the number in the EPROM file the program will occupy.

Normally, after power is applied to

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the BASIC-52 device, you must type a space character to initialize the 8052AH's console port. As a convenience, BASIC-52 contains a PROG1 command. This command programs the resident EPROM with the data-transmission-rate information. The next time the MCS BASIC-52 device is powered up, i.e., reset, the chip will read this information and initialize the serial port with the stored data-transmission rate. The sign-on message will be sent to the console immediately after the BASIC-52 device completes its reset sequence. The space character no longer needs to be typed.

The PROG2 command does everything the PROG1 command does, but instead of signing on and entering the command mode, the BCC-52 board immediately begins executing the first program stored in the resident EPROM.

By using the PROG2 command, it is possible to run a program from a reset condition and never connect the BCC-52 board to a console. In essence, saving PROG2 information is equivalent to typing ROM 1 and RUN in sequence. This is ideal for control applications, where it is not always possible to have a terminal present. In addition, this feature lets you write a special initialization sequence in BASIC or assembly language and generate a custom sign-on message for specific applications.

Powering Up the Board

The best way to check out the BCC-52 board is to run it with the minimum hardware first. With only ICs 1, 2, 4–7, 9–11, 13, and 15 installed, we have an 8K-byte RAM-only system. After applying power, BASIC-52 clears the internal 8052AH memory; initializes the internal registers and pointers; and tests, clears, and sizes the external memory.

BASIC-52 then assigns the top of external RAM to the system-control value (MTOP) and uses this number as the random-number seed. BASIC-52 assigns the default-crystal value, 11.0592 MHz, to the system-control value (XTAL) and uses this default value to calculate all time-dependent functions, like the EPROM programming timer and the interrupt-driven real-time clock. Finally, BASIC-52 checks external memory location 8000 to see if the data-transmission-rate information is stored. If the data-transmission rate is stored, BASIC-52 initializes the data-transmission-rate generator (the 8052AH's special-function register, T2CON) with this information and signs on. If not, BASIC-52 interrogates the serial-port input and waits for a space character to be typed (automatic data-transmission-rate detection).

If you have entered nothing on the console device, BASIC-52 will appear inoperative to the uninitiated. Simply type a space, and the console device should display the following:

```
*MCS-52(tm) BASIC Vx.x*
READY
>
```

To see if the processor is operating correctly, we type the following:

```
>PRINT XTAL, TMOD, TCON,
 T2CON
```

BASIC-52 should respond with the control and special-function values:

```
11059200 16 244 52
>
```

A Word About the BASIC

As I mentioned earlier, BASIC-52 is oriented toward process control and is significantly more powerful than a tiny BASIC. Since most of you are familiar with BASIC, I will not describe individual instructions like DO. . . WHILE and FOR. . . NEXT. Instead, I'd like to point out the pertinent features that demonstrate the exceptional small-package performance of the BCC-52 board.

MCS BASIC-52 contains a minimum-level line editor. Once a line is entered, you cannot change the line without retyping it. However, it is possible to delete characters while a line is in the process of being entered. This is done by inserting a rubout or delete character (7F). The rubout character will cause the last character entered to be erased from the text input buffer. Additionally, pressing Control-D will cause the entire line to be erased.

Variables and Expressions

The range of numbers that can be represented in BASIC-52 (in decimal) is +1E−127 to +0.99999999E+127.

It has eight digits of significance. Numbers are internally rounded to fit this precision. Numbers can be entered and displayed in four formats: integer, decimal, hexadecimal, and exponential, for example, 129, 34.98, OA6EH, 1.23456E+3.

Integers are numbers that range from −32,768 to +32,767 decimal. All integers can be entered in either decimal or hexadecimal format. A hexadecimal number is indicated by placing the letter "H" after the number. When an operator like AND requires an integer, BASIC-52 will truncate the fraction portion of the number so that it will fit the integer format. All line numbers are integers.

A variable can be either a letter (e.g. A, X, I), a letter followed by a number (e.g., Q1, T7, L3), a letter followed by a one-dimensioned expression (e.g., J(4), G(A+6), I(10*SIN(X))), or a letter followed by a number followed by a one-dimensioned expression (e.g., A1(8), P7(DBY(9)), W8(A+B)). Variables with a one-dimensioned expression are called dimensioned or arrayed variables. Variables that involve only a letter or a letter and a number are called scalar variables.

BASIC-52 allocates variables in a static manner. Each time a variable is used, BASIC-52 allocates 8 bytes specifically for that variable. This memory cannot be deallocated on a variable-by-variable basis. If you execute a statement like Q=3, later on you cannot tell BASIC-52 that the variable Q no longer exists and free up the 8 bytes of memory that belong to Q. You can clear the memory allocated to variables with a CLEAR statement.

Relative to a dimensioned variable, it takes BASIC-52 much less time to find a scalar variable. That's because a scalar variable has no expression to

(continued)

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evaluate. If you want to make a program run as fast as possible, use dimensioned variables only when you have to. Use scalar variables for intermediate variables, then assign the final result to a dimensioned variable.

An expression is a logical mathematical term that involves operators (both unary and dyadic), constants, and variables. Expressions can be simple or quite complex, e.g., 12*EXP(A)/100, H(1)+55, or (SIN(A)*SIN(A)+COS(A)*COS(A))/2. A standalone variable [var] or constant [const] is also considered an expression.

Real-Time Operation

After RUN is typed, all variables are set equal to zero, all BASIC-evoked interrupts are cleared, and program execution begins with the first line number of the selected program. The RUN command and the GOTO statement are the only ways you can execute a program in the command mode. Program execution can be terminated at any time by typing a Control-C on the console device.

Unlike some BASIC interpreters that allow a line number to follow the RUN command (e.g., RUN 100), BASIC-52 does not permit such a variation on the RUN command. Execution always begins with the first line number. To obtain the same functionality as the RUN[ln num], use GOTO[ln num] in the direct mode.

The CLOCK1 statement enables the software real-time clock in BASIC-52. The special-function operator time is incremented once every 5 ms after the CLOCK1 statement has been executed. The CLOCK1 statement uses timer/counter 0 in the 13-bit mode to generate an interrupt once every 5 ms. Because of this, the special-function operator time has a resolution of 5 ms.

BASIC-52 automatically calculates the proper reload value for timer/counter 0 after the crystal value has been assigned (i.e., XTAL = value. If no crystal value is assigned, MCS BASIC-52 assumes a value of 11.0592 MHz). The special-function operator time counts from 0 to 65,535.995 seconds. After reaching a count of 65,535.995 seconds, time overflows back to a count of 0.

The interrupts associated with the CLOCK1 statement cause BASIC programs to run at about 99.6 percent of normal speed. That means that the interrupt handling for the real-time-clock feature consumes only about 0.4 percent of the total processor time. This is small interrupt overhead. The CLOCK0 statement disables or turns off the real-time-clock feature.

The TIME statement is used to retrieve and/or assign a value to the real-time clock after the CLOCK1 statement enables it. TIME = 5 presets the real-time clock to 5 seconds, while ONTIME 30,100 causes the program to jump to line 100 when the real-time clock reaches 30 seconds.

Finally, PWM might be useful to literally add bells and whistles to your next control application. PWM stands for pulse-width modulation. It generates a user-defined pulse sequence on IC5 pin 3.

The statement appears as PWM 50,50,100. The first expression following PWM is the number of clock cycles the pulse will remain high. A clock cycle is equal to 1.085 microseconds (11.0592-MHz crystal). The second expression is the number of clock cycles the pulse will remain low; the third expression is the total number of cycles you want to output. All expressions in the PWM statement must be valid integers, and the minimum value for the first two expressions is decimal 20.

These are only a few of the 103 commands, statements, and operators in BASIC-52. The *User's Manual* describes them in detail.

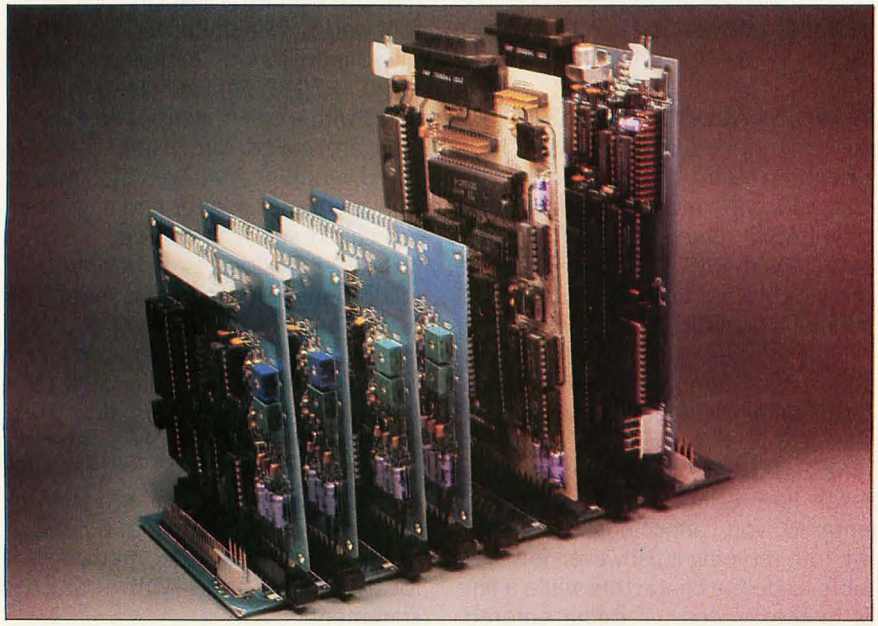

Photo 3: *The* BCC-52 *and Term-Mite boards can be combined with other* BCC-*series peripheral devices to create control and data-acquisition systems. Here, they are combined with four* BCC-13 *8-channel, 8-bit* A/D *converter boards to make a 32-channel data-acquisition system.*

In Conclusion

This was a hard article for me to write, but not for any of the reasons you might think. So much is built into this compact board that I am impatient to use it, and it was hard to sit down and write. Unfortunately, documentation is the drudge work side of engineering.

It won't take long to put the BCC-52 board into some serious applications. It might be a single-board computer, but its configuration does not stop with a single board. The BCC-52 is BCC-series Z8-bus-compatible and can be expanded using many of the

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projects and boards I've already designed. For example, monitoring temperatures, controlling motors and heaters, and reporting events are adequately handled by existing power I/O, serial and parallel expansion, and A/D converter boards (see photo 3).

This BASIC-52 project has just started. Because of its power, I am inspired to further develop applications and peripheral support devices. While a specific time has not been chosen, I'll be back in a few months with the next chapter on the BCC-52.

Circuit Cellar Feedback

This month's feedback is on page 376.

Next Month

Go beyond the Z80 with the Circuit Cellar SB180 computer. ■

Diagrams and data pertinent to the 8052AH-BASIC chip are reprinted courtesy of the Intel Corporation.

Editor's Note: Steve often refers to previous Circuit Cellar articles. Most of these past articles are available in book form from BYTE Books, McGraw-Hill Book Company, POB 400, Hightstown, NJ 08250.

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